Henry Draper.

(*Minute prepared by Geo. F. Barker, Secretary American Philosophical Society, for Proceedings, December 1, 1882.*)

Henry Draper was born on the 7th of March, 1837, in Prince Edward county, Va., his father being at the time Professor of Chemistry and Natural Philosophy in Hampden Sidney College. When but two years old, his father was called to the chair of Chemistry in the University of the City of New York, and removed to that city in 1839. Henry was entered as a regular scholar, first in the primary, and subsequently in the preparatory schools connected with the University, and at the age of fifteen, entered the collegiate department as an undergraduate. Upon the completion of his sophomore year, however, he abandoned the classical course and entered the medical department, from which he graduated with distinction in 1858. The following year he spent in Europe. While abroad he was elected on the medical staff of Bellevue Hospital; and on his return he assumed the position and discharged its duties for eighteen months. In 1860, at the age of 23, he was elected Professor of Physiology in the Classical department of the University, and, in 1866, to the same chair in the Medical department; being soon after appointed Dean. In 1873, he severed his connection with the medical department; and in 1882, upon the death of his father, he was elected Professor of Chemistry in the Classical department; a position which he held until the close of the current academic year.

Reared in direct contact with science and scientific thought, as Dr. Draper was, it is not surprising that at an early age he developed a decided preference for scientific pursuits. His father was a man not only of the widest scientific knowledge, but he was also of exceptional ability as an investigator. To live in contact with this genial and learned man, was of itself a scientific education of the highest type. Henry was early taken into his confidence in scientific matters, and was called upon to assist his father not only in his lectures, but also in his investigations. The scientific spirit which presses forward unflaggingly in the pursuit of truth and which wrests from Nature the profoundest secrets by patient and long continued application, had long been characteristic of the elder Draper; it was now fully developed in his son. While yet a medical student, he undertook a most difficult research upon the functions of the spleen; and, conscious of the inaccuracies incident to drawings, he illustrated this research—afterward published as his graduating thesis—with microphotographs of rare perfection for those early days, all taken by himself. While engaged with the microscope in making these photographs, he discovered that palladious chloride had a remarkable power in darkening or intensifying negatives; an observation subsequently of much value in photography.

During his sojourn in Europe, he had visited the great reflecting telescope of Lord Rosse at Parsonstown, Ireland. The sight of this instrument

inspired him with a desire to construct one like it, though on a smaller, scale, and turned his attention toward astronomy and astronomical photography. Soon after his return he began the construction of a metal speculum, fifteen inches in diameter, completing it in 1860. Subsequently he accepted a suggestion contained in a letter written to his father by Sir John Herschel, and abandoned speculum metal for silvered glass. In the year 1861, he made several mirrors of silvered glass, 15½ inches in diameter. The best of these was mounted as a Newtonian telescope, in a small wooden observatory erected at Hastings-on-Hudson, his father's country seat. The details of grinding, polishing, silvering, testing and mounting this reflector, all of which he did with his own hands, were published as a monograph by the Smithsonian Institution. This publication has had a deserved popularity, and has become the standard authority on the subject. Much experimental work was done with this telescope ; that which is best known, being his photograph of the moon. More than 1500 original negatives were taken with this instrument. They were one and a quarter inches in diameter, but such was the perfection of their detail that they bore enlargement to three feet, and in one case to fifty inches without injury. The success of this mirror stimulated him to undertake a still larger one, and, in 1870, he finished a silvered glass mirror, twenty-eight inches in diameter. A new dome was built for it by the side of the old one, the mounting being equatorial, and the telescope Cassegrainian ; though subsequently a plane secondary mirror was substituted for the convex one. A refracting telescope of five inches aperture was attached to the tube of the reflector, as a finder. With this larger instrument, work was at once begun upon photographic spectra ; and, in 1872, a beautiful photograph was obtained of the spectrum of α Lyræ (Vega), which showed the dark lines ; a step far in advance of anything which had been accomplished in this direction up to that time. Desiring to make simultaneous eye-observations, Dr. Draper, in 1875, placed upon the same axis, a refracting telescope of twelve inches aperture, made by Alvan Clark & Sons. In 1880, this was exchanged for another refractor by the same makers, of eleven and a half inches aperture, but furnished with an additional lens to serve as a photographic corrector. The work of stellar spectrum photography went steadily on, the new refractor now doing the principal work. More than a hundred such photographs were made, most of these having upon the same plate a photograph of the spectrum of Jupiter, Venus, or the moon. These latter, giving the solar lines by reflection, enabled the stellar lines to be identified by direct comparison.

Reflecting on the extreme sensitiveness of the dry-plate process in photography, he was led to experiment on the reproduction of nebulæ by its means ; and on the 30th of September, 1880, he succeeded by an exposure of fifty-seven minutes in obtaining a photograph of the nebula in Orion. Satisfied now that the idea was an entirely feasible one, he devoted himself uninterruptedly to securing the greatest possible perfection in the driving clock and to improving the details of manipulation. In March, 1881, a

second and much superior photograph of this nebula was secured after an exposure of 104 minutes. And finally, a year later, on the 14th of March, 1882, he succeeded in making a successful exposure of 137 minutes, and in producing a most superb photograph, which showed stars of the 13.7 magnitude, invisible to the eye, and in which the faint outlying regions of the nebula itself were clearly and beautifully shown. This unrivaled photograph, by far the most brilliant success yet achieved by celestial photography, will ever have a very high astronomical value, since by a comparison with it of photographs of this nebula, taken many years subsequently, changes which are going on in it may be traced and their history written. Ordinarily the photograph of a spectrum is more difficult than one of the object itself. But in this case it is not so. The spectrum being of bright lines, the light is localized and readily impresses the plate. Moreover, any error in the rate of the clock or any tremors of the instrument, which are fatal to the nebula, count for little in photographing its spectrum; since the image is thereby simply shifted off the slit and no injury results to the definition. Many excellent photographs of the spectrum of the nebula in Orion were obtained by Dr. Draper, however, the chief interest in which consists in the fact that beside the characteristic bright lines, there are traces of continuous spectrum in various parts of the nebula, suggesting the beginning of condensation.

Beside the work done at his observatory at Hastings, which may be called astronomical work proper, Dr. Draper occupied himself with collateral questions of not less importance, in the admirably equipped physical laboratory he had built in connection with his residence in New York City. It was here, in 1873, that he made the exquisite, and to this day unequaled photograph of the diffraction spectrum. The region from wave-length 4350, below G, to wave-length 3440 near O, was contained upon a single plate. The Roman astronomer Secchi reproduced this photograph as a steel plate for his great work on the Sun, and the British Association, in 1880, endorsed it as the best known standard spectrum by publishing a lithograph of it in their Proceedings. The grating used to produce this photograph was one of Mr. Rutherfurd's superb plates, ruled with 6481 lines to the inch. It was in his New York laboratory, too, that he made the most important discovery of his life, perhaps; that of the existence of oxygen in the sun. After months of laborious and costly experiment, he succeeded, in 1876, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate, with their edges in complete contact; thus enabling the coincidence or non-coincidence of the lines in the two spectra to be established beyond a doubt. On examining the spectrum of oxygen thus photographed, he saw that while the lines of the iron and the aluminum used as electrodes, coincided, as they should do, with their proper dark lines in the sun's spectrum, the lines of oxygen agreed with bright solar lines. Whence the important conclusion announced by him, 1st, that oxygen actually existed in the sun, now for the first time proved; and, 2d, that this gas exists there under conditions either of tempera-

ture or pressure, or both, which enable it to radiate more light than the contiguous portions of the solar mass. This view of the case however, required radical modification in the then accepted view of the constitution of the sun ; a modification which he pointed out and advocated. So exceptional were these results, and especially the conclusions from them, that it was hardly to be expected that they should be at once accepted. Dr. Draper, however, in this, as in all his work, was his own severest critic. Increasing constantly his appliances and perfecting his methods he produced, in 1879, another photograph on a much larger scale, which showed the coincidences which he claimed, especially of groups of lines, so unmistakably as to leave no question of the fact in a mind free from bias. To strengthen still more the evidence on the subject, he had planned for execution the present winter, a research upon the spectra of other non-metallic gases, in the hope that some of these, too, would be found represented as bright lines in the sun spectrum.

In 1878, he was the director of a party organized by himself to observe the total eclipse of the sun of the 29th of July. His familiarity with the locality led him to select Rawlins, Wyoming, an important station on the Union Pacific Railway, as the objective point. The result justified his selection. The expedition was entirely successful, and the observations which were made were of great value. By means of his splendid apparatus, Dr. Draper himself obtained an excellent photograph of the corona and also a photograph of its diffraction spectrum which was apparently continuous. In 1880, he obtained a number of spectra of Jupiter in connection with stellar work. On examining one of these spectra, the photograph appeared to him to show that the planet really furnished a certain amount of intrinsic light. The exposure on Jupiter was fifty minutes, the spectrum of the moon being taken in ten. The original negative was sent over to his friend, Mr. A. C. Ranyard, who presented it to the Royal Astronomical Society. In June, 1881, he took several excellent photographs of the comet, and also of its spectrum. With a slit and two prisms he obtained three photographs of the spectrum, with exposures of 180, 196, and 228 minutes, respectively. On each plate, a comparison spectrum was also photographed.

Upon the organization of the United States Commission to observe the Transit of Venus in 1874, Dr. Draper's great attainments in celestial photography pointed him out at once as the man best suited to organize the photographic section, and he was accordingly appointed Director of the Photographic Department. He went at once to Washington, entered heartily into the work, and during three entire months devoted himself to the labor of organizing, experimenting and instructing ; declining subsequently all compensation for the time thus spent. Although his duties at home prevented him from joining any of the expeditions, yet so instrumental had he been in making the transit observations a success, that upon the recommendation of the Commission, Congress ordered a gold medal to be struck in his honor at the Philadelphia Mint. This medal

is 46 millimeters in diameter. It has the representation of a siderostat in relief upon the obverse, with the motto: "Famam extendere factis, hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M. D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

Professor Draper was appointed, in 1861, Surgeon of the Twelfth Regiment of New York Volunteers; a position which he accepted and in which he served with credit. In 1876, he was made one of the Judges in the Photographic Section of the Centennial Exhibition. In 1875, he was elected a member of the Astronomische Gesellschaft. In 1877, he received an election to the National Academy of Sciences; and in the same year he was made a member of the American Philosophical Society. In 1879, he was elected a Fellow of the American Association for the Advancement of Science. In 1881, the American Academy of Arts and Sciences worthily enrolled him among its members. In 1882, the University of Wisconsin and the University of New York conferred on him, almost simultaneously, the degree of LL.D.

For several years it had been Dr. Draper's custom to join his friends, Generals Marcy and Whipple, of the Army, in the early fall, for a few weeks' hunting in the Rocky mountains. In 1882, the party left New York on the 31st of August, went by rail to Rock creek, on the Union Pacific Railway, and from there went north in the saddle; reaching Fort Custer, on the Northern Pacific Railway, near the middle of October. During the two months of their absence the party rode fifteen hundred miles on horseback, as Dr. Draper estimated. When above timber line early in October, they encountered a blinding snow storm with intense cold and were obliged to camp without shelter. Dr. Draper reached New York on the 25th of October. Ordinarily, he returned refreshed and invigorated with the splendid exercise of the trip; but this year the distance traveled seemed to have been too great, and this, together with the hardships encountered, seemed to have wearied him. Pressure of delayed business awaited him and occupied his time at once. Moreover, the National Academy was to meet in New York in November; and he was to entertain them as he had always done. This year the entertainment was to take the form of a dinner. In order to offer them scientific novelty, he determined to light the table with the Edison incandescent light, the current being furnished from the machine in his laboratory. But the source of power being a gas engine, and therefore intermittent, a disagreeable pulsation was observable in the light. To obviate this he contrived an ingenious attachment to the engine whereby at the instant at which the speed was accelerated by the explosion of the gas in the cylinder, a lateral or shunt circuit. should be automatically thrown in, the resistance of which could be varied at pleasure. With his admirable mechanical skill he extemporized the device from materials at hand and found it to work perfectly. The dinner was given on the evening of November 15th, and was one of the most brilliant ever given in New York; about forty academicians, together

with a few personal friends as invited guests, sitting at table. But Dr. Draper's overwork now told upon him ; slightly indisposed as he had been before, he was unable to partake of food, and a premonitory chill seized him while at the table. As soon as the dinner was over, he took a hot bath, thinking thus to throw it off. But while in the bath a second and severer chill of a decidedly congestive type attacked him, and it was only with the greatest difficulty that he could be carried to his bed. His warm friend and former colleague, Dr. Metcalfe, was at once summoned and pronounced the attack double pleuritis. The best of treatment and the most careful nursing seemed for two or three days to be producing an effect for the better. But on the Sunday following, heart complication developed and he died about 4 o'clock in the morning of Monday, the 20th of November.

Viewed from whatsoever standpoint, the life of Henry Draper appears as successful as it was earnest, honest and pure. His devotion to science was supreme ; to him no labor was too severe, no sacrifice too great, if by it he could approach nearer the exact truth. The researches he had already made, and much more those he had projected, involved the largest expenditure of his time and means. But such was his delight in his scientific work, and his enthusiasm in carrying it on, that he was never happier than when hardest at work in his laboratory, never more cheerful than when most zealously laboring with his superb telescopes. Moreover, he was as eminent as a teacher of science as he was as an investigator. His lectures were simple, clear and forcible. They held the interest of the class and awakened their enthusiasm while they enriched the student's store of knowledge and strengthened his powers of observation and of reason. In the laboratory he was keen, thorough and impartial, while at the same time considerate and helpful ; ever striving to encourage honest endeavor and to assist the earnest worker.

Still another sphere of labor, however, made demands upon his time. In 1867, he married Mary Anna, the accomplished daughter of Courtlandt Palmer, of New York. Upon Mr. Palmer's death, in 1874, Dr. Draper became the managing trustee of an immense estate and, with his characteristic energy and efficiency, entered at once upon the task of reducing it to a basis of maximum production with the minimum amount of attention. The responsibility which thus rested upon him, the harassing demands of tenants, the endless details of leases, contracts and deeds, and the no less annoying complications of necessary law suits, worried him incessantly. And had it not been for his unsurpassed business capacity, he might have failed. But he was equal to the demand upon him, and within a few years, order had come out of confusion, and a few hours at his office daily enabled all to flow along smoothly.

To indicate the esteem in which Dr. Draper was held by his confrères in science, the following passages may be quoted from an excellent biographical notice of him written by Professor Young, of Princeton : "In person he was of medium height, compactly built, with a pleasing address,

and a keen black eye which missed nothing within its range. He was affectionate, noble, just and generous; a thorough gentleman, with a quick and burning contempt for all shams and meanness; a friend most kind, sympathetic, helpful, and brotherly; genial, wise and witty in conversation; clear-headed, prudent and active in business; a man of the highest and most refined intellectual tastes and qualities; a lover of art and music, and also of manly sports, especially the hunt; of such manual skill that no mechanic in the city could do finer work than he; in the pursuit of science, able, indefatigable, indomitable, sparing neither time, labor nor expense."

"Excepting his early death, Dr. Draper was a man fortunate in all things; in his vigorous physique, his delicate senses, and skillful hand; in his birth and education; in his friendships; and especially in his marriage, which brought to him not only wealth and all the happiness which naturally comes with a lovely, true-hearted and faithful wife, but also a most unusual companionship and intellectual sympathy in all his favorite pursuits. He was fortunate in the great resources which lay at his disposal, and in the wisdom to manage and use them well; in the subjects he chose for his researches and in the complete success he invariably attained."

Such a man as this it is whose name we are sorrowfully called upon to strike from the roll of our living membership. Professor Draper was a man among men, a scientist of the highest type. Stricken down in the midst of his life-work, at the early age of 45, the bright promise of his noble life is left unfulfilled. What brilliant researches in his favorite science he would have made, we can never know. But with a mind so richly endowed and so thoroughly trained, with an experimental ability as earnest as it was persistent, with facilities for investigation which were as perfect as they are rare, with abundance of time and means at his disposal, and above all, with a devoted wife, who keenly appreciated the value of his scientific work, was ever at his side as his trusty assistant and always shared in the glory and the honor of his discoveries, we may be sure that, had he been permitted to reach the age of his honored father, results would have been reaped by his labors which would have added still brighter lustre to the science of America.

Map of the Terminal Moraine.

On page 476 it is recorded in the minutes of the meeting, October 6, 1882, that Prof. Henry Carvill Lewis read a paper on the course of the great Terminal Moraine through Pennsylvania, studied by him as volunteer Assistant of the Second Geological Survey of Pennsylvania, and described in his unpublished Report of Progress, Z, illustrated by photograph pictures taken by Mr. E. B. Harden, Topographical Assistant to the Survey.